Pre-Engineering
Pre-Engineering General Pathway
Engineering Technology, General (CIP 15.0000)

Maine Statewide Standard

Framework, Duties and Tasks:

1. Understand Safety Practices
    a. Understand the causes of and the dangers from electric shock and explain methods to prevent it.
    b. Demonstrate an understanding of protective devices including personal protective equipment (PPE).
    c. Understand machine safety considerations, including emergency stops, and “deadman” switches, explain usage, and point out devices on the specific machines used.
    d. Demonstrate knowledge of lock-out/tag-out procedures.
    e. Demonstrate general laboratory safety practices.
    f. Understand and demonstrate safety zones around operating equipment.
    g. Know locations of the safety equipment and how to use it.
    h. Demonstrate use of common tools correctly and safely.
    i. Obtain and utilize Safety Data Sheets (SDS).
    j. Understands existence of multiple national, state, and organization safety standards (OSHA, ABS, NFPA70E, etc.).
2. Understand Nature and Scope of Engineering
    a. Explain the purpose of engineering.
    b. Identify the various career paths available in engineering.
        i. Identify available engineering paths.
        ii. Identify other related engineering fields.
        iii. Identify and differentiate between technicians, engineers, and researchers delineating educational paths.
    c. Identify engineering achievements through history, tracing the history of an invention and evaluate its effects on society and the environment.
    d. Identify historical engineering role models, including minorities and women.
    e. Identify problems for engineers to solve in the future.
    f. Describe and compare the relationships of technology, engineering and science.
    g. Understand the difference between engineering disciplines and job functions
    h. Research and present the educational requirements to become an engineer.
    i. Research and present a career field in engineering to include pay, location specific requirements, working conditions, education, description of tasks, outsource potential, anticipated growth, potential for growth.
    j. Recognize that technology is how humans modify the world around them to meet their needs and wants or to solve problems and extend their capability
3. Professional Attributes and Ethics
    a. Define attributes associated with being a successful engineer.

b. Understand how gender-bias, racial-bias and other forms of stereotyping and discrimination can adversely affect communications within an engineering team (in compliance with state and federal regulations such as EEOC).
c. Understand how ethics influences the engineering process.
d. Understand how social, environmental and financial constraints influence the engineering process.
e. Understand that an engineering team must work together to solve problems, with each team member having individual and collective responsibilities.
f. Understand the professional and legal responsibilities associated with being an engineer.
g. Explain ethical implications of technology on our society, environment, and economy.
h. Understand the role of out-sourcing in the engineering process (i.e. safe labor practices, environmental concerns, quality control).

4. Measurement and measurement tools dimensions and units
   a. Understand and be able to convert between the common SI and Standard units for length, area, volume, force, pressure, mass, speed, work, temperature, torque, density, and energy.
   b. Understand the difference between scientific notation and engineering. notation, common unit prefixes, and common terms.
   c. Demonstrate reading a variety of measuring tools: vernier scale, calipers, micrometer, tape measure, engineers scale, architects scale, etc.
   d. Identify and classify types of fasteners including thread classification.
   e. Understand and be able to convert between fractions and decimals.
   f. Demonstrate an understanding of tolerance, precision, and accuracy.
5. Workplace Readiness
   a. Understand necessity for personal grooming, proper attire,
   b. Understand employer expectations, including promptness, respect, work ethic, and professionalism.
   c. Understand hourly, salaried, overtime, pay schedule, benefits, pay deductions, and pay scale.
   d. Understand how to respond in a job interview.
   e. Understand how to complete a job application, fill out a W2 form, and write a thank you letter.
   f. Create a résumé.
   g. Write a business letter.
   h. Create a portfolio with work completed, including photos, written research, professional letters, hard copy of presentations, examples of engineering calculations using a spreadsheet, résumé, community service documentation, awards and certificates.
6. Project Management
   a. Understand project planning charts such as Gantt, PERT, etc.

b. Use the tools of estimating, statistical analysis, bills of material, etc.
c. Understand data-based decision making considering cost, life cycle, alternative concepts.
d. Explain quality control and provide examples within projects.
e. Understand the dynamics and the roles and responsibility of a functional team.

7. Codes and Standards
   a. Identify pertinent codes and design standards.
   b. Understand the difference between codes and standards.
   c. Research a project for codes and standards to insure compliance.
8. Documentation, communication, and presentation
   a. Develop verbal and written communication skills appropriate to the professional and client audiences (i.e. specifications, proposals, test standards, inquiries, and negotiations).
   b. Write a research paper using proper citing standards.
   c. Write a formal proposal.
   d. Keep a daily log/engineering notebook.
   e. Produce technical papers with embedded graphs, tables, charts and write proposals.
   f. Make freehand sketches including orthographic, isometric, and perspective.
   g. Use CAD and 3D Solid Modeling software to make scale drawings of components and assemblies.
   h. Make simple blueprints, schematics, maps, diagrams, flowcharts, graphs, and tables.
9. Problem Solving and the Engineering Design Process
   a. Identify problem-solving steps and procedures.
   b. Explain prototyping and production.
   c. Compose and diagram the product development lifecycle including continuous redesign and re-engineering to improve the product.
   d. Describe the basic technological system model which includes input, process, output, and feedback.
   e. Differentiate open and closed loop systems.
   f. Identify the technological system inputs (resources) as materials, time, energy, tools/machines, capital, information, space, and human resources.
   g. Discuss management strategies of resources including the following: reducing, recycling, reusing, and renewing resources.
   h. Identify and explain the three major components of the engineering process in developing a product: Problem solving/design; Production; and Management.
   i. Recognize and be able to discuss system outputs as having desirable and undesirable, intended and unintended, and immediate and delayed aspects.
10. Understand and apply design principles in developing a process, product, or system.

a. Understand and apply design principles including the following: structure, function, appearance, safety, durability, reliability, economic and financial feasibility, marketability, quality control, environmental impacts, manufacturability, maintainability, and human factors of engineering (ergonomics), ease of use, ease of assembly, social appropriateness.
b. Classify technologies as inventions or innovations.
c. Explain components of set up, machining, casting, molding, welding, and finishing
d. Identify how technological innovations are created or enhanced through connections to other fields of study.
e. Understand the concepts and value of planned failure, durable goods and nondurable goods.
f. Assess trade-offs in terms of the outputs of technological systems and analyze trade-offs in optimizing product design.
g. Utilize briefs and specifications (criteria and constraints) in order to maximize a solution in design work; differentiate between a problem/opportunity and a solution.
h. Investigate and research data that will be useful in developing a design solution using a variety of mediums which may include the following: interview, Internet, databases, books, magazines, video, observation, measurement, and surveys.
i. Brainstorm and creatively generate a multitude of possible solutions to the stated problem or opportunity.
j. Analyze potential solutions based on design principles and make a decision as to the best solution.

11. Use existing and emerging technology, to investigate, research, and produce products and services, including new information.
    a. Use electronic reference materials to gather information and produce products and services
    b. Employ web based communications responsibly and effectively to explore complex systems and issues
    c. Use information and communication technologies to synthesize, summarize, compare, and contrast information from multiple sources
    d. Discern the quality and value of information collected using digital technologies and recognize bias and intent of the associated sources
    e. Assess the value of various information and communication technologies to interact with constituent populations as part of a search of the current literature or in relation to the information task
12. Electrical Systems
    a. Understand the causes of and the dangers from electric shock and explain methods to prevent it
    b. Define and explain the following electronic terms and concepts: electricity, electronics, conductor, insulator, semi-conductor, series circuit and parallel circuit, analog and digital circuits, power, voltage, current, and resistance.
    c. Create schematic drawings to facilitate experimental measurements of electrical circuits.

d. Apply Ohms and Kirchhoff's laws to simple series and parallel circuits
e. Differentiate between AC and DC electricity.
f. Understand the basic operating principles of electrical motors and generators.
g. Assemble an electronic circuit, showing an understanding of the use of schematics, function of basic electronic components, and electronic measurement.
h. Use a multi-meter to measure resistance and voltage

13. Mechanical Systems
    a. Define and identify the six simple machines: wheel, lever, pulley, wedge, inclined plane, screw, that provide mechanical advantage
    b. Define and explain the characteristics of mechanical system functions being that of changing speed, power, distance, and direction and apply them in mechanical systems.
    c. Assemble a mechanical system using gears, pulleys and levers, using an understanding of the basic components of mechanical components and being able to calculate mechanical advantage.
14. Fluid Power
    a. Define and explain advantages and disadvantages of pneumatic versus hydraulic systems (i.e., quick, slow, powerful, clean, dirty, cost, etc.), demonstrating an understanding of the concept of fluid power as it relates to air and liquid.
    b. Evaluate and select specific fluid power sources for different functions
    c. Create a flow diagram schematic sketch and compare it to an actual fluid power circuit
    d. Mathematically calculate and explain the work being done by a specific fluid power device
    e. Assemble a fluid power system, showing the function of the basic fluid power components: pump, tank, valve, cylinder, piston, and actuator
    f. Demonstrate proper setup and adjustment of a fluid power system.
    g. Explain critical importance of safety relief devices in a fluid power system
15. Structures and structural analysis
    a. Define and explain basic structural terminology including: compression, tension, torsion, stress, strain, triangulation, deformation, moment, static load, and dynamic load.
    b. Analyze a simple truss using scalars and vectors to mathematically determine types and magnitude of forces acting on the truss
    c. Utilize structural analysis software to design and test a bridge, size beams, analyze loadings, and compare materials
    d. Build a scale version of a bridge and test
    e. Explain the importance of factors of safety in relationship to structural design
    f. Give example of engineering failures and explain the reasons for the structural failure
    g. Explain how shape affects strength.
    h. Define, calculate, and use centroid and Moment of Inertia
    i. Use a graph to show the relationship between stress and strain
16. Thermodynamics

a. Utilize the first and second laws of thermodynamics, describing the concept and function of a heat engine of student choice.
b. Calculate and explain heat loss in a building, define R factor
c. Calculate and explain infiltration in relationship to ventilation requirements, heat loss, enthalpy, and heat gain
d. Calculate and explain heat gain within a building
e. Calculate solar gains associated with orientation, system efficiency, and utilization
f. Calculate and explain conduction, convection, and radiation
g. Identify energy sources including solar, geothermal, wind, tidal, chemical oxidation, electrical, and potential
h. Explain fuel cell operation and potential usage

17. Materials and Materials Testing
    a. Identify and differentiate the five basic categories of solid engineering materials.
    b. Compare and contrast the physical properties of organic, metals, polymers, ceramics, and composites.
    c. Trace the production of raw material to finished product.
    d. Identify practical applications of each material category to engineered products and processes.
    e. Collect, analyze, and test samples of the four basic materials.
    f. Document and present laboratory data related to studies of material classifications.
    g. Identify and document the properties of materials.
    h. Design an experiment to identify an unknown material.
    i. Formulate conclusions through analysis of recorded laboratory test data for presentations in the form of charts, graphs, written, verbal, and multi-media formats.
    j. Analyze word problems about forces acting on materials.
    k. Define and state examples of the major categories of Production Processes.
    l. Analyze a component of a product and describe the processes used in its creation.
    m. Interpret a drawing and produce a part.
    n. Give an oral presentation on the production processes used to create products from a category of materials and a demonstration about one of the processes.
    o. State the difference between mass and weight.
18. Quality Control
    a. Utilize a variety of precision measurement tools to measure appropriate dimensions, mass, and weight.
    b. Understand and explain why companies have a need for quality control and describe what customers and companies refer to when the term “quality” is used.
    c. Calculate the mean, median, mode, and standard deviation for a set of data and apply that information to an understanding of quality assurance.
    d. Explain the difference between process and product control.

e. Distinguish between the characteristics of quality in a final product and the control of quality in each step of a process.
f. Understand how control charts are used in industry and will be able to predict whether a process is “out of control,” or not by using a control chart.
g. Describe and safely conduct destructive and non-destructive material testing and use the data collected through these tests to compute and document mechanical properties. Analyze a product that breaks and be able to explain how the material failed.

19. Engineering for Quality, Reliability and Efficiency
    a. Diagram a system and identify the critical components.
    b. Identify situations of supplying and outsourcing.
    c. Identify the order and methodology of the assembly process.
    d. Estimate mathematically chance of failure of a system given information on certain components.
    e. List the causes of failure and be able to propose solutions.
    f. Prepare and defend a position on an ethical engineering dilemma.
    g. Research the engineering, legal, social, and ethical issues related to a final design developed in a case study.
    h. Analyze an engineering failure for the purpose of presenting an aural report which identifies; causes, damage done, design failures, and other areas where the failure has impacted the environment or society.
    i. Prepare a written report explaining their analysis of an engineering failure.
20. Linear and Trajectory Motion
    a. Explain the difference between distance traveled and displacement.
    b. Design and build a device for the purpose of conducting experiments of acceleration, displacement, and velocity.
    c. Explain how velocity and acceleration are calculated.
    d. Calculate range and initial acceleration from data they record from experiments.
    e. Analyze test data and utilize the results to make decisions.
21. Automation
    a. Create a program to control a student-constructed device to perform an automated operation.
    b. Select and apply concepts of mechanical, electrical, and control systems in solving design problems.
    c. Formulate a plan for evaluating the functioning of student constructed sorting device and make appropriate changes in design, circuitry or programming.
    d. Demonstrate and defend student-designed solution to the design problem in an oral presentation to the class.